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(54) Pump for heavy gases.

(57) A pump comprising two co-operating rotors (13, 14) which is suitable for pumping heavy gases. The pump has an inlet/exhaust manifold (30) which offers in its inlet substantially no obstruction to gas flow. The manifold has an inlet passage (33) of a bell shape and the outlet manifold comprises a passage (40) which has a shape which varies in cross-section from part annular to circular. Owing to the shape of the manifold, pulsations within the fluid being pumped are reduced and pressure loss through the manifold is reduced. Thus, power requirement for a specific duty is reduced for the pump.

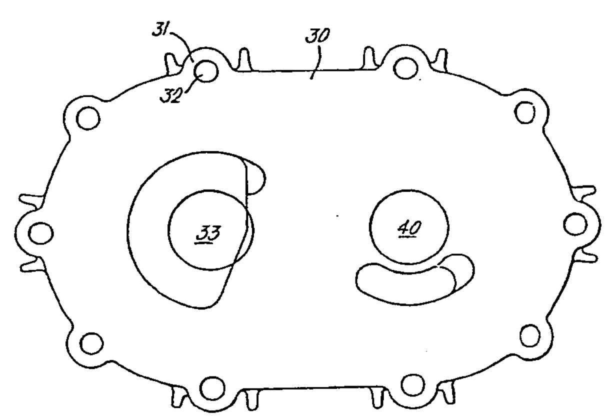

Fig.4

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COMPLETE DOCUMENT

This invention relates to pumps for pumping heavy gases.

When pumping heavy gases, such as uranium hexafluoride, pumps which operate satisfactorily in pumping light gases such as air, tend to overheat and in some designs throughput through the pump tends to be reduced compared with light gases.

An object of the present invention is to tend to provide a pump which is able to pump heavy gases more efficiently than hitherto.

According to the present invention, a pump for pumping heavy gases comprising two co-operating rotors,is characterised in that the rotors each have an arm for sweeping gas from the pump inlet to its outlet, the arms causing a compression of the gas during part of their movement, an inlet/outlet manifold being provided on the pump, which inlet/outlet manifold includes passages for inlet of gas and for outlet of gas, each of which passages has a different cross section at opposite ends, the passages being constructed to provide a minimal velocity of gas travelling through them, whereby pressure losses of gas within them is minimal, said minimal velocity change being achieved by minimising mechanical obstruction from within the passages, the minimal pressure loss reducing pulsations within the gas owing to said compression and hence allowing efficient pumping of the gas In this way, transisition between an input conduit and the pump and an output conduit and the pump is rendered smooth so that impedances do not increase gas pulsation difficulties. Since the inlet passage has a relatively large volume, a buffer volume of gas may be provided.

The inlet passage may be bell-shaped and may be disposed with its widest cross-section inside the pump. The outlet passage may vary from a part annular cross-section within the pump to a circular cross-section where the manifold is connected to the output conduit.

An embodiment of the present invention will now be described by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a sectional view of a pump,

Figure 2 is a diagrammatic view of a gas pumping part of the pump,

Figure 3 is an end view of a manifold for a pump,

Figure 4 is an annular view to Figure 3, but of a slightly modified manifold,

Figure 5 is a section on IV-IV of Figure 4,

Figure 6 is a section on V-V of Figure 4,

Figure 7 is a diagrammatic view of fluid flows within the pump,

Figure 8 is a graph of performance parameters of the pump in one operational condition,

Figure 9 is a graph of performance parameters of the pump in a different operational condition.

Figure 10 is a second diagrammatic view of flow patterns occuring in the pump, and

Figure 11 is a graph of performance of a pump having flows similar to those shown in Figure 10.

Reference is directed firstly to Figure 1, in which there is shown a pump for pumping heavy gases. An inlet for the pump is

generally indicated by 1 and an outlet by 2. The inlet 1 and outlet 2 form part of a manifold 3, which manifold 3 is bolted to a housing of the pump 4 by means of studs 5 and 6, which themselves are secured by nuts 7. The description is to be read as though a manifold 30 (to be described below) were substituted for manifold 3, which is only illustrated to show manifold positioning. A motor for the pump is generally indicated by 8 and this motor drives the pump via a shaft 9. The shaft 9 carries the pinion 10, which pinion engages a second pinion 11. The pinion 11 is carried upon a shaft 12 . The shafts 9 and 11 carry gear pump members 13 and 14, respectively, within the manifold 3. The configuration of the members 13 and 14 can be seen more clearly in Figure 2 to which reference is now also directed.

The pump gears 10 and 11 and the motor 8 are sealed from gas entering and leaving the pump by means of an endplate 17 which carries seals 18 for the shafts 9 and 12. The shafts 9 and 12 are mounted in tapered roller bearings 19 and 20, respectively. The motor 8 has a housing 21 which is secured to a plate 22 bolted to the casing 4 by bolts 23. Further seals 24 and 25 are provided on the shafts 9 and 12 respectively, on that part of the casing 4 to which the plate 22 is secured. Therefore, it can be seen that it is not possible for gas to escape from the manifold 3 and the region where the pump members 13 and 14 are located into the remainder of the pump.

Reference is now directed to Figures 3, 4, 5 and 6, in which a manifold 30 of the type fitted to the pump in place of the manifold 3 (of Figures 1 and 2) is shown. The manifold, now designated as 30,

is secured to the remainder of the pump by means of boss portions 31 containing passages 32 for bolts or studs. The inlet passage into the manifold is in the form of a segment of a circle for the area of cross section of fluid flow. Two recesses 34 and 35 are provided on the segment. In Figure 4, there is shown a modified manifold without the recesses. In section, the inlet passage 33 is bell-shaped as may be seen from Figure 5, the innermost part of the inlet being the part of widest diameter. The bell shape provides a buffer volume of gas for damping pulsations. Also, in Figure 5 it can be seen that an attachment flange 36 is provided for attachment of the inlet manifold to for example pipes (not shown). The recesses 34 and 35 which can be seen on the end view of the inlet manifold in Figure 3, correspond to a slight convolution of the flow passage as it goes through the manifold. The manifold 30 has an outlet passage which can be most clearly seen reference to Figure 6. The outlet passage indicated by 40 is widest at its outermost end and narrowest at its innermost end in Figure 6. The cross-section of the flow is circular at its outermost end and in the form of a part annular (the part being ninety degrees) passage at its innermost end. The passage widens to one hundred and ten degrees as it approaches the circular part.

Reference is now directed to Figure 7, which shows a diagrammatic model of operational parameters of the pump. In Figure 7, the pump is indicated by 60. Input pressure to the pump is indicated by P1 and outlet pressure by P2. However, these are not the pressures seen by the pump, since there has to be a pressure loss in the direction of flow owing to an inlet port impedance and an outlet port

impedance. Therefore, the inlet pressure to the pump is indicated by P3 which is that pressure which occurs after an inlet port impedance indicated by 11. The outlet pressure from the pump is indicated by P4, which pressure is a pressure above the outlet pressure P2 of an amount equal to the pressure lost through an outlet port impedance indicated by 12. There is also an impedance in the pump caused by pressure lost through the seals on the shafts 9 and 12 (see Figure 1). This impedance is indicated by 13 and 14 for each shaft. There is also an impedance 5 caused by the rotor clearance, this impedance being shown as unidirectional. Different symbols are used for impedance in different part of the pump. The interrelation of these impedances and their significance will be explained in more detail in operation below.

Reference is now directed to Figure 8, in which pump pressure is plotted as ordinate and location along a pump as abscissa. The graph of Figure 8 shows, as a full curve, the pressure of air and, as a dotted curve, the pressures of uranium hexafluoride. P1 and P2 are the same for the pump in both cases. However, from the graph it can be seen that there is a greater drop between P1 and P3 in the case of uranium hexafluoride than air, and similarly in the case of pressure P4 and P2. Therefore, the pump has to do more work with uranium hexafluoride than with air. Consequently, a problem may arise with overheating of the pump.

Reference is now directed to Figure 9, which is drawn in a similar fashion to Figure 8. Figure 9 shows a pump in a situation where P1 equals P2, that is to say when there is no throughput of

fluid through the pump. This is a point that occurs in operation, at that point where the pump members referred to above in connection with Figure 1 as 13 and 14 are at their compression point in their cycle which will be explained in more detail below.

Reference is now directed to Figure 10, in which like reference numerals to Figure 6 are used for like parts. This Figure relates to the situation described above in connection with Figure 9, that is the situation where no flow is passing through the pump. It is to be understood that the position of no flow is a theoretical one mentioned here for the purpose of explanation. Naturally, in real life, the situation is a dynamic one and there is a continual variation in pressure in the pump sympathetic to rotor movement. In the no-flow situation, it is possible for pulsations which are set up in the fluid that is being pumped to reach their peak amplitude, the pulsations being indicated schematically by arrows 13, 14 which are drawn in opposite directions to represent opposite phases of the pulsations. The situation may be further explained with reference to Figure 11, which should now also be referred to and which is constructed in relation to Figure 10 in a similar manner to that in which Figure 9 was constructed in respect of Figures 7 and 8. In Figure 11, a typical magnitude of the pulsations can be seen.

Operation of the pump is now described with reference in particular to Figure 2 and Figures 7 to 11. The pump member 13 rotates in a clockwise manner and the pump member 14 in an anti-clockwise manner. Fluid is drawn in through the inlet and exhausted through the exhaust. In Figure 2, it can be seen, that the

members 13 and 14 have arms 96 and 97, which come together during part of the stroke of the pump. This position is shown in Figure 2 and corresponds to a compression position of the pump. Therefore, fluid is drawn in and pushed around by the member 13, slightly compressed in the interaction between the members 13 and 14 and then pushed out of the exhaust manifold by the member 14. As has been explained above, with reference to Figure 6, the inlet port and outlet port have impedances 11 and 12 which become of significance when uranium hexafluoride is being pumped when compared with the pumping of air. Therefore, it is important that these impedances be reduced, so that too much power is not used by the pump tending to cause overheating thereof. Therefore, the inlet of the manifold 30 is constructed so as to have reduced mechanical obstruction therein, ie substantially no mechanical obstruction to ingress of the heavy gas so that a minimal gas velocity is achieved. Also, the inlet widens out in the bell shape described above with reference to Figure 5. However, such an enlarged inlet port may give rise to rotor slippage. Therefore it might be thought that provision of the wider inlet is, in fact, not a worthwhile exercise because of the increased rotor slippage; ie although there is a gain in respect of loss of inlet pressure, this is counterbalanced by the increase in rotor slippage. Therefore, in normal practice it would be customary to have a smaller inlet with mechanical obstructions in the passage.

Another consideration which is material to the design of the inlet passage is that of avoidance of pressure fluctuations in the manifold, since these fluctuations absorb motor power and may tend to

cause undesirable overheating. On first consideration, it would appear that uranium hexafluoride would be an improved fluid for the purpose of pumping in the pump compared with air. This is because the volumetric slippage between the rotors for a given pump outlet and inlet pressure is less for a dense gas than a light gas thereby enhancing the pump throughput, the relative density of uranium hexafluoride to air being 12:2. Further, since gamma, the specific heat ratio of uranium hexafluoride is about 1.064 compared with 1.41 for air, for a given inlet and outlet pressure, the outlet temperature due to adiabatic compression would be significantly less. However, in practice, it is found that the higher impedance of the parts in the presence of a heavy gas coupled with the inherent oscillatory nature of the pump produces high frequency, high amplitude and therefore high inertial changes in the gas, requiring higher power with consequential temperature increase. Therefore, the problem of fluctuation has to be addressed as well. A reduction in built-in pump pressure ratio reduces pulsation amplitude of the pulsations of the fluid and in consequence reduces power demand and allows the pump to run at a lower temperature. Therefore, if the difference between P1 and P2 can be decreased, the pulsation amplitude is reduced. This reduction can be achieved by provision of inlet and outlet manifolds of relatively low impedance. Therefore, a construction of inlet such as that shown above in Figure 5 is advantageous in reducing the pulsation amplitudes as well as decreasing the pressure difference for reasons described above.

Consequently, a design of inlet according to Figure 5, is part

of the present invention, although it might appear that in fact it would cause problems with loss of inbuilt compression of the pump.

Considering the outlet passage in the manifold, it can be seen that this, in fact, is a slightly convoluted path and is not such a low resistance as the inlet passage described above. However, this passage, indicated at 40 in Figure 5, is nonetheless larger than would normally occur in a pump of a type described. The outlet passage has a size which is determined by comparison with that of the inlet passage and is determined to have dimensions such that the pulsations described above in connection with Figure 10 and 11 are reduced to a minimum, yet compression is not lost.

From the foregoing, it can be seen that there is a reduction of pressure loss through the inlet and outlet manifold. Consequently, the throughput characteristics of the pump are enhanced and since the pump is operating more efficiently, the pump operating temperature is reduced at a specific duty. In addition, the shaping of the parts relative to each other is so arranged that the dead period, when both inlet and outlet ports are closed, is reduced, thereby reducing the pressure pulsation amplitudes which are normally far greater with heavy gases than with light gases, thus, the power requirement for a specific duty is reduced with a corresponding reduction in pump temperature.

From the above description, it can be seen that an improved pump is provided.

CLAIMS

1. A pump for pumping heavy gases comprising two co-operating rotors, characterised in that the rotors each have an arm (96, 97) for sweeping gas from the pump inlet to its outlet, the arms causing a compression of the gas during part of their movement, an inlet/outlet manifold being provided on the pump, which inlet/outlet manifold includes passages for inlet (33) of gas and for outlet (40) of gas, each of which passages have a different cross section at opposite ends, the passages being constructed to provide a minimal velocity of gas travelling through them, whereby pressure losses of gas within them is minimised, said minimal velocity change being achieved by minimising mechanical obstruction from within the passages, the minimal pressure loss reducing pulsations within the gas owing to said compression and hence allowing efficient pumping of the gas.

2. A pump as claimed in Claim 1, characterised in that the inlet passage is bell-shaped (33) and is disposed with its widest cross-section inside the pump.

3. A pump as claimed in Claim 1, characterised in that the outlet passage (40) varies from a part annular cross section within the pump to a circular cross section where the manifold is connected to the output conduit.

4. A pump as claimed in Claim 2, characterised in that a buffer volume is provided by said bell shape for damping pulsations in the gas.

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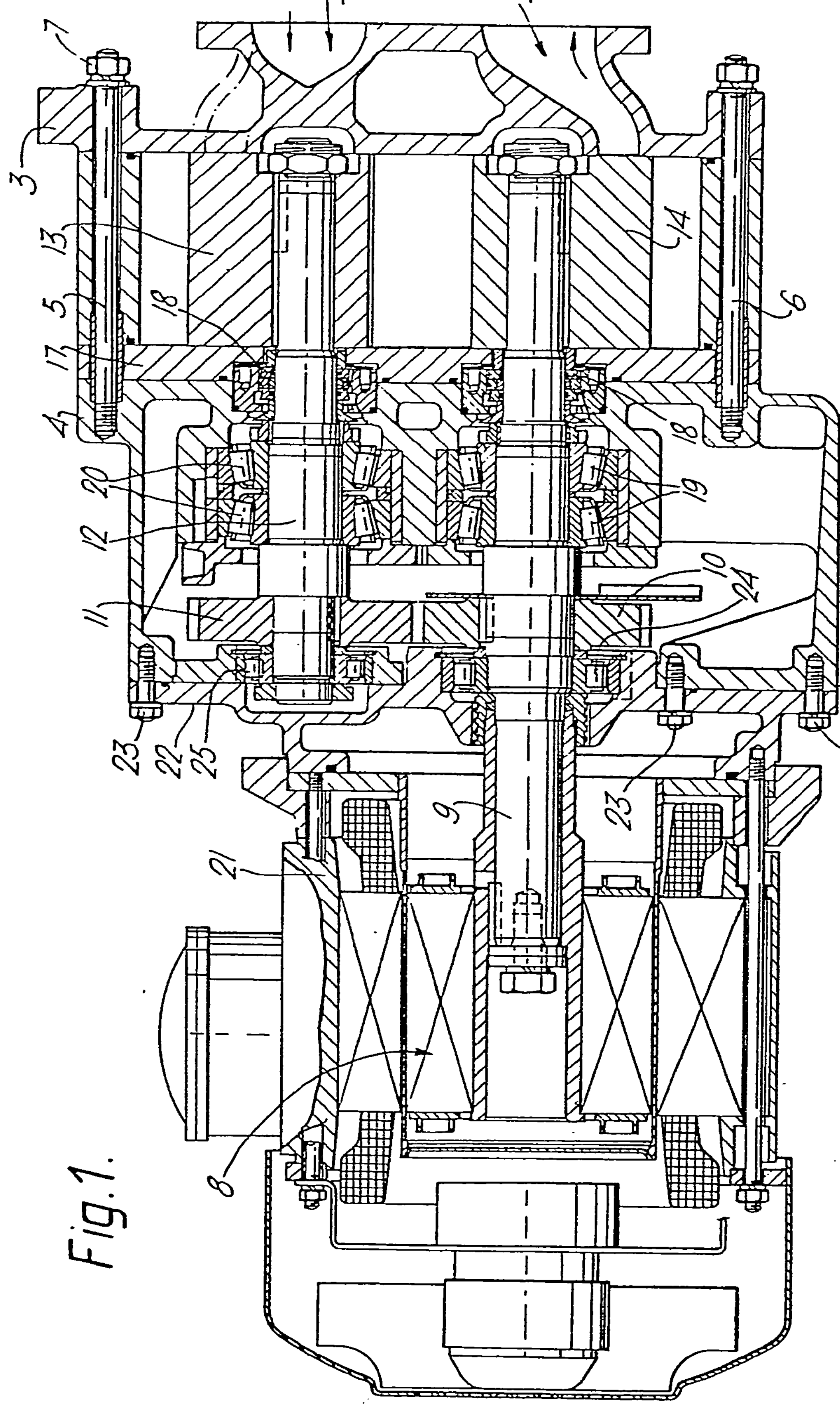


Fig.1.

Fig.6.

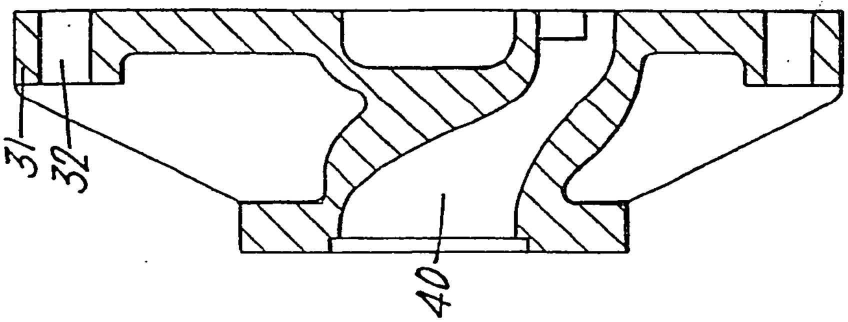


Fig.5.

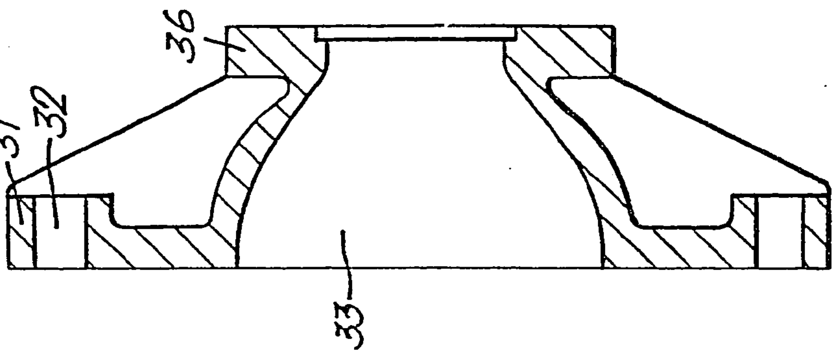


Fig.2.

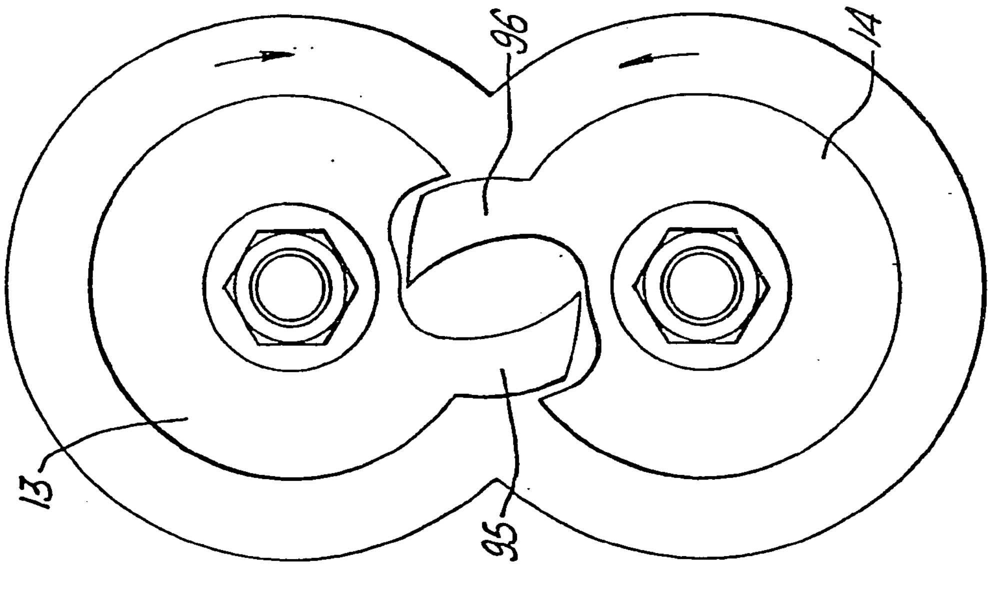
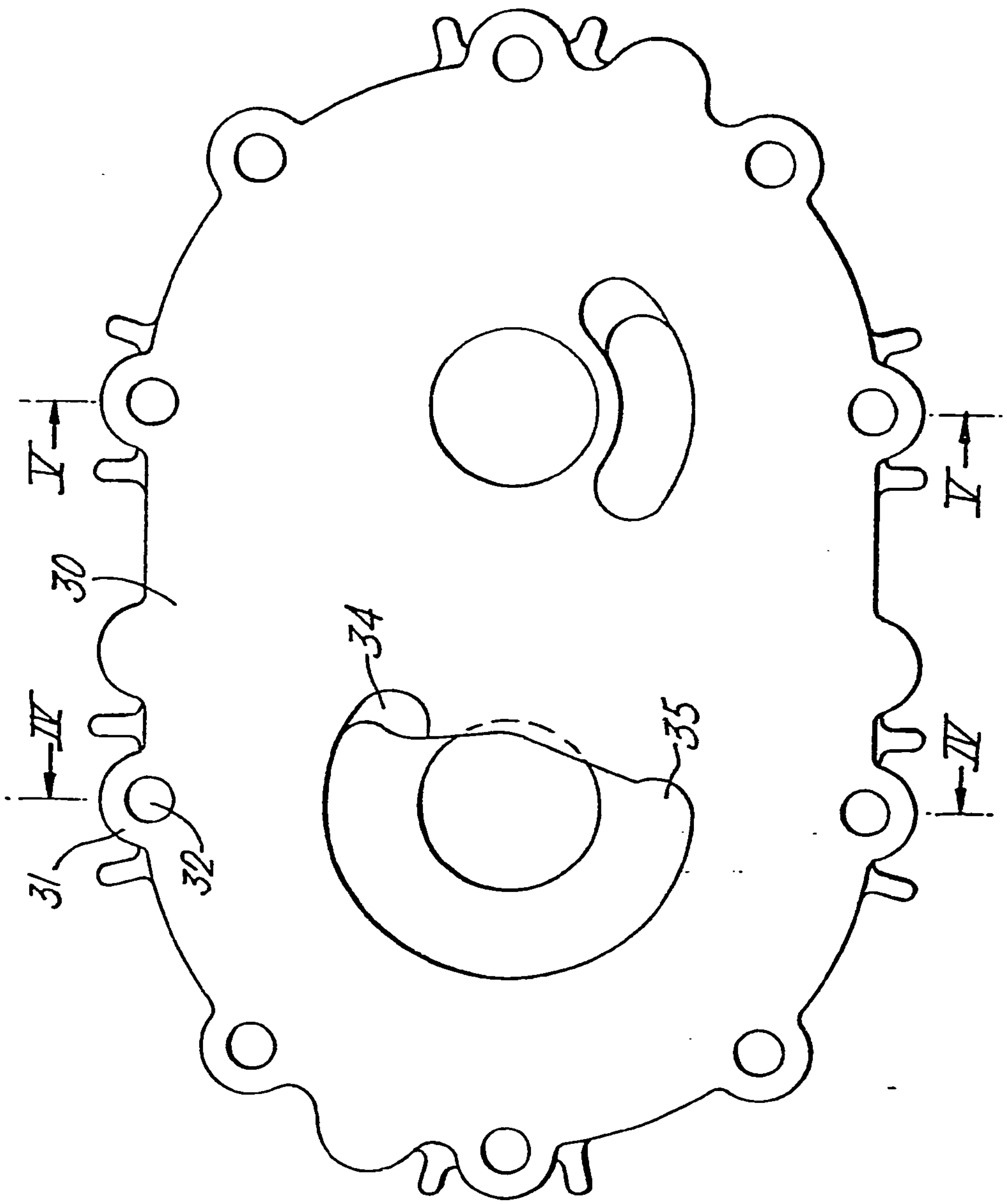


Fig. 3.



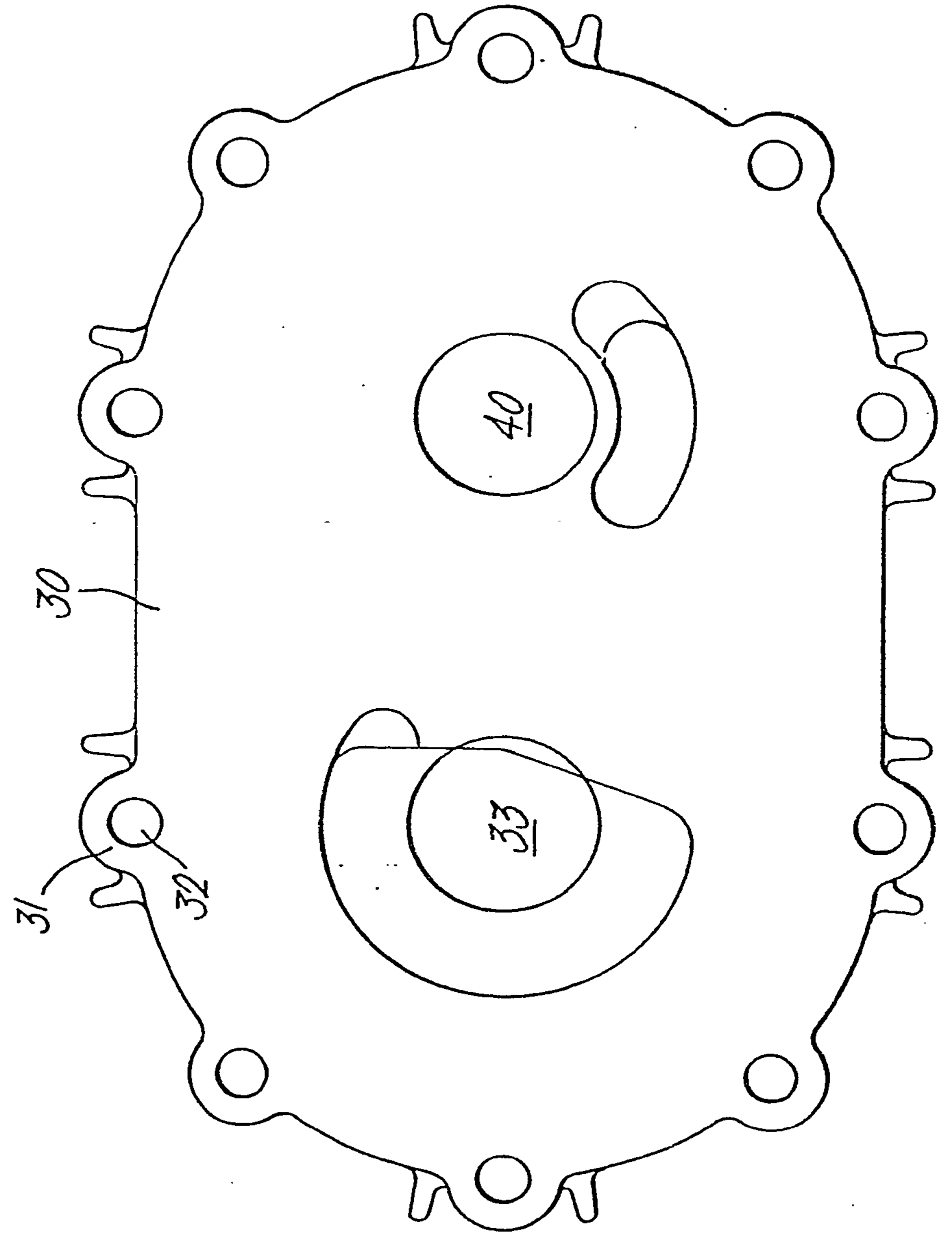


Fig. 4

Fig. 7.

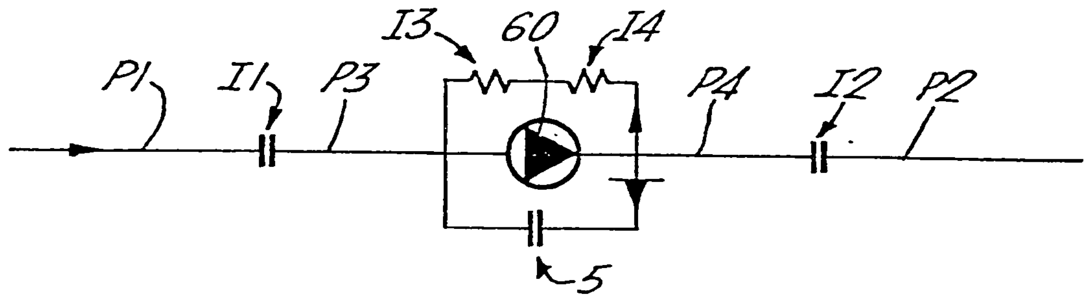


Fig. 8.

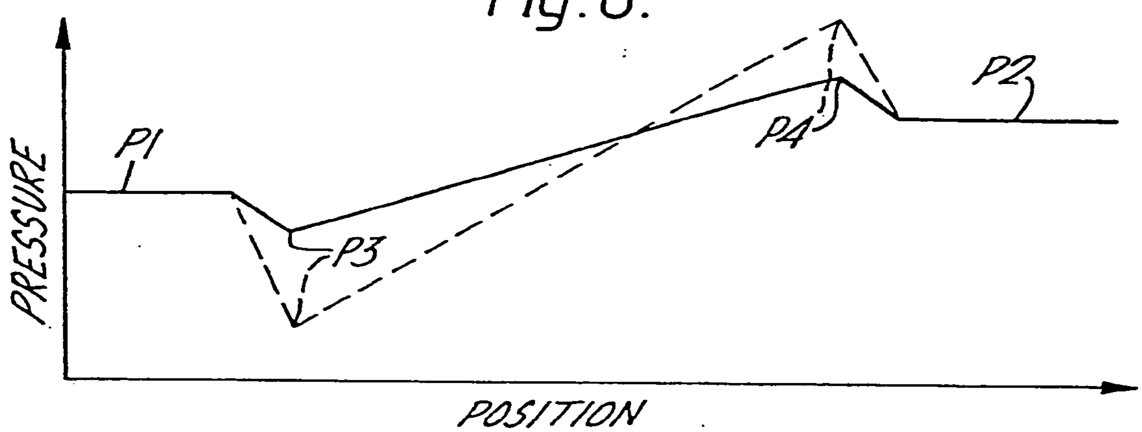


Fig. 9.

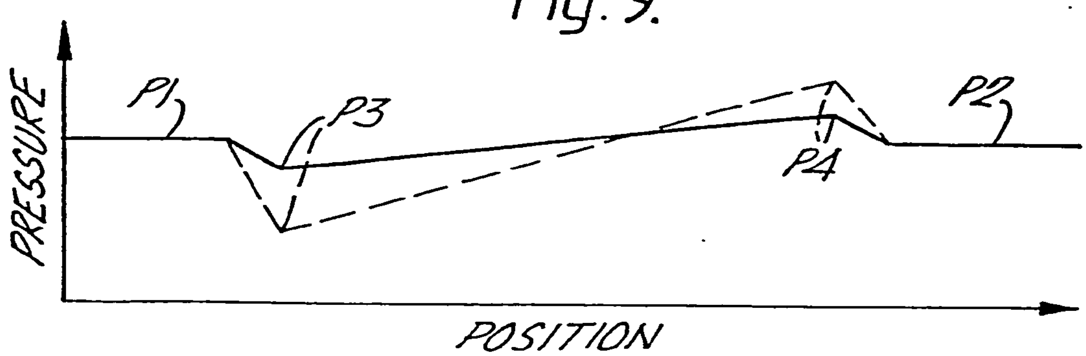


Fig. 10.

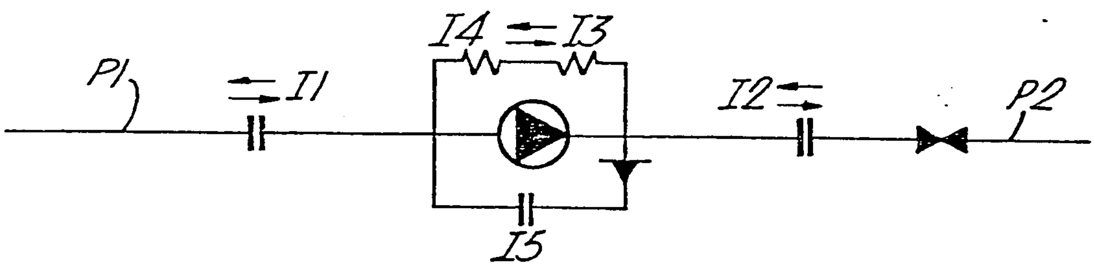
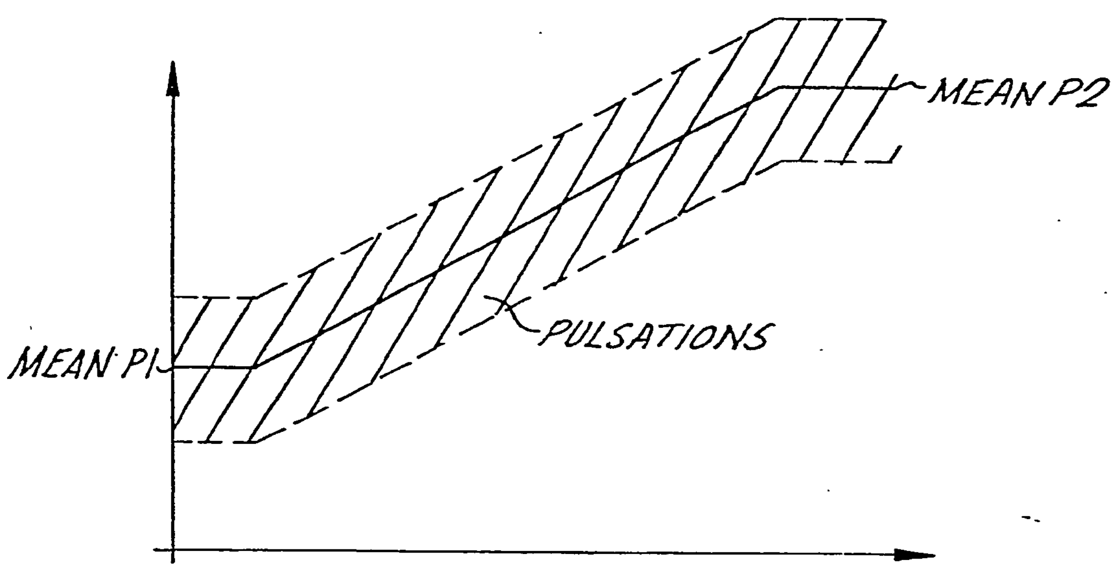


Fig. 11.



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EUROPEAN SEARCH REPORT

Application number

EP 81 30 3882

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl.3)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
A	FR - A - 636 382 (MINNE) * page 1, last paragraph especially lines 59 to 61; page 2, lines 48 to 86; figures 1,6,7 * --	1,2,3	F 04 C 29/08
A	US - A - 2 469 936 (TABBERT) * column 1, lines 43 to 47; figure 2 * --	2	
			TECHNICAL FIELDS SEARCHED (Int. Cl.3)
A	US - A - 3 844 696 (STILES) * column 4, lines 15 to 21 and 59 to 64; figure 5 * --	1,4	F 04 C F 01 C
A	US - A - 3 513 476 (MONDEN) * column 2, lines 33 to 36; figure 2 * -----------	4	
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X	The present search report has been drawn up for all claims		&: member of the same patent family, corresponding document

Place of search	Date of completion of the search	Examiner
The Hague	11-12-1981	KAPOULAS

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